REPORT NO. 77-4

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COMPARISON OF TWO COMPUTERIZED MAPPING SYSTEMS FOR ANALYSIS, STORAGE AND RETRIEVAL OF FOREST INSECT AND DISEASE SURVEY DATA

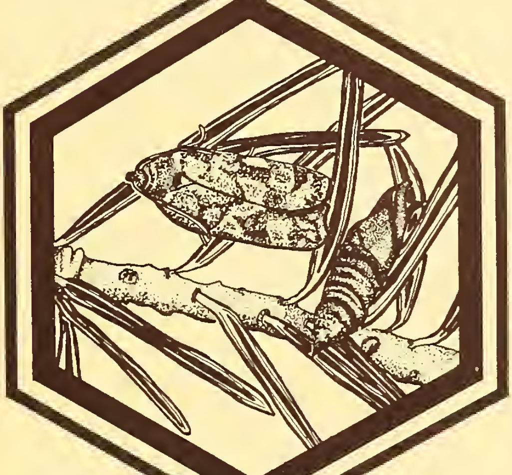

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TABLE OF CONTENTS

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COMPARISON OF TWO COMPUTERIZED MAPPING SYSTEMS FOR ANALYSIS, STORAGE AND RETRIEVAL OF FOREST INSECT AND DISEASE SURVEY DATA

Robert W. Young 1/

ABSTRACT

Two closed polygon computerized mapping systems, PLOT and WRIS, were evaluated for use in analysis, storage and retrieval of Forest Insect and Disease survey data. Both systems provided reliable storage and retrieval systems for historic information. PLOT, or one very similar, is recommended for futher evaluation by Forest Insect and Disease Management.

INTRODUCTION

Surveys for detection and evaluation of forest insects and diseases are a major activity of FI&DM. The purpose of these surveys is to detect, delineate, and estimate relative intensities of insect and disease activity. In the western United States, these surveys are conducted in mid to late summer with results available by late fall. Maps showing location of damage and tabular summaries are prepared and distributed to resource managers to aid in management decisions.

Computerized mapping is a potential tool to assist in processing Forest Insect and Disease survey data. Its implementation as a data management system for FI&DM may provide the following benefits:

1. Reduce time required to summarize survey data. Provide acreage statistics to the land manager (Federal, State and private) within a relatively short time frame to implement follow-up action.

2. A standard data base from which historical files could be extracted to:

   a. Identify chronic areas of forest insect and disease mortality,

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b. Produce composite maps showing location of outbreak areas by year for impact-benefit cost analysis.

3. Ability to super-impose insect and disease data over existing computer maps of timber types (i.e., stocking levels, age classes), soil types, land use designations, or road system maps to increase capability of Forest Insect and Disease Management specialists to relate incidence of insect and disease damage to certain key environmental factors and land management constraints.

4. Standardized National, State or Regional summaries of insect and disease losses from which priorities for action programs can be determined.

Types of Mapping Systems

Computerized mapping systems fall into two broad classes - grid systems and closed polygon systems.

Grid Systems have the following general characteristics:

1. Maps are subdivided into small rectangular cells of equal area identified by one or two characters of a line printer. Computer input is generally hand-coded from grid forms overlaid on the base map.

2. Printer characters are used as codes which define the attributes of the area they occupy. Areas which have the same attributes are identified by identical codes.

3. Boundaries between separate areas are implicit through changes in the codes but are not explicitly drawn. Delineation of areas is only approximate.

4. The smallest delineable area is the unit cell.

5. Extraction is by cell code (characteristic) only.

6. Area statistics represent global counts of all cells of identical codes. The size of individual areas of like attributes must be obtained by visual count.

7. Overlaying can be performed routinely only for map layers of the same scale and having identical boundaries. Grid systems do not permit change of scale internally or in the output phase.

8. Hardware requirements include the host computer, keypunch, card reader, high-speed printer, and (in some cases) time-share terminal. Output maps are produced on a high-speed line printer or time-share terminal.

9. Learning the functions and operation of the systems tends to be of low degree of difficulty for properly documented systems.

Closed Polygon Systems have the following general characteristics:

1. Maps are divided into polygons according to selected attributes. Computer input is generated by tracing polygon boundaries from the field map and subsequently digitizing the copy to obtain numeric data. This process can be carried out manually on a digitizer or automatically with the aid of an optical scanner or other means.

2. Each polygon has a unique identifier. Polygons can be extracted by number, characteristic, or by selected area. Areas are calculated and reported for each individual polygon but may also be obtained as sums for polygons with like attributes.

3. Maps for the same areas but consisting of different attributes (ownership and insect layers) can be overlayed. The area of intersection is computed and summarized.

4. Hardware requirements include a computer, line printer, digitizer and plotter. For interactive work, a time-share terminal is required. Scanning and photographic preparation of scanner input is frequently contracted to vendors but may also be done in-house.

5. Operation of the polygon plotting system requires a substantial amount of training and technical support.

Due to the nature of FI&DM input data, only closed polygon systems were considered for the evaluation.

Forest Service Postion On Computerized Mapping

Significant developments have occurred recently in the management of computer systems by the Forest Service. A special task force, Systems Development Action Planning Team (SDAPT), was formed to analyze and recommend ways to work with computers more effectively. Recommendations of this task force have been or are currently being implemented (Leisz *et al*., 1975).

Two recommendations, now operative, are relevant to computerized mapping:

1. National systems are assigned to those program areas for which the system is mainly used. The recipient of such systems will be responsible for system operation, maintenance, and documentation.

2. Computer mapping responsibilities were assigned to the Director of Engineering. The charter establishes goals, objectives, and guidelines for operating a unified computer mapping system. The mapping development work is within the Geometronics Development Group.

   The Resource Information Display System (RIDS) has the responsibility for meshing the mapping systems currently in use together resulting in a common system for mainline users. The resultant National system(s) can then be used by FI&DM specialists with minimum developmental work.

OBJECTIVES

The objective of this evaluation was to compare the efficiency and applicability of two alternative closed polygon mapping systems, PLOT and WRIS, for summarizing and displaying data acquired from Forest Insect and Disease detection surveys.

Evaluations were made as to whether:

1. System can provide data storage and retrieval,

2. Mapping outputs are compatible to a data management system for reporting data in tabular form, and

3. Outputs could serve as an adequate sampling frame for other intensive surveys, such as a state-wide mountain pine beetle loss survey.

METHODS

Systems Evaluated

Two closed polygon systems, PLOT and WRIS, were evaluated. Both systems appeared to meet the minimum requirements for application for FI&DM needs. Both PLOT and WRIS produced similar results from a previous bench mark test (Schwarzbart *et al*., 1976).

Criteria for selecting the two systems include the following:

1. System is currently in useable (operational) status.

2. Input data can be done by digitizing or by scanning.

3. System is operated at FCCC.

4. Costs are not prohibitive.

5. Overlay procedure is simple.

6. Produces a map.

Brief overviews describing each system follows:

PLOT (Robertson, personal communication) is a polygon layer overlay system. Its principal function is to overlay areas (polygons) extracted from two map layers, create a new layer consisting of the areas of overlap, and calculate acreages of the new polygons. PLOT stores a record of coordinates which describe the boundary of a polygon, plus an alpha-numeric label for the polygon. Input is by manual digitizing. Output is a listing of polygons, their labels and acreages, a summary of acreage for polygons with like identifiers and, if desired, a plotted map of polygons, each with its label and acreage shown. Specific polygons or polygon groups can be extracted from a layer. Label changes are permitted in the extract process. Either entire maps or extracted polygons may be overlayed. PLOT is capable of handling "donuts." Donuts are polygons with polygons, the inner polygon not attached to the outer one.

WRIS (Wildland Resource Information System) (Schwarzbart et al., 1976) is a polygon map information system utilizing optical scanner or manual digitizer input. Success in handling complex maps is attributed to the use of optical scanner input devices. WRIS provides a methodology for storing and repeatedly processing land inventory information assembled on maps. Outputs from the system are individual polygon acreages, summations of acreages by specified selection criteria and/or line plotter output showing selected geographical areas. Map layers may be superimposed and new intersecting polygons can be delineated by the system. The composite overlay map data can be manipulated in the same manner as the original. This overlaying process can be repeated as many times as desired.

Evaluation Area

The northern half of the Targhee National Forest and adjacent lands in Idaho, (Figure 1) was used for the evalation. The total area encompasses approximately 1,000,000 acres and contains an active

outbreak (ca 300,000 acres) of mountain pine beetle, Dendroctonus ponderosae Hopk. in lodgepole pine. Detailed surveys to determine the status and trend of the outbreak have been conducted by the Intermountain Region of the U.S. Forest Service since 1965.

Data Input

U.S. Forest Service Class C Planimetric Maps, scale ½-inch = 1 mile, depicting status of mountain pine beetle infestation in the target area were obtained from the Intermountain Region. Three levels of information were extracted from these maps.

1. Land ownership

   a. Targhee National Forest.

   b. Other National Forest lands - portions of the adjoining R-1 Beaverhead and Gallatin National Forests.

   c. Private lands.

   d. National park lands (portions of Yellowstone National Park).

2. Status of the mountain pine beetle infestation - 1975.

3. Status of the mountain pine beetle infestation - 1976.

Geographic boundaries included in the base ownership layer are:

	Latitude	Longitude
SW	44° 7' 30"	111° 45' 00"
NW	44° 45' 00"	111° 45' 00"
NE	44° 45' 00"	111° 0' 00"
SE	44° 7' 30"	111° 0' 00"

Both PLOT and WRIS require mylar (plastic) overlays. The process involves inking the boundaries of each parcel of land delineated from the sketch map or from the ownership map.

A large light table was used to prepare mylar overlays. The original survey map was taped down and a piece of mylar put over it. Then using a No. 2 Rapidiograph pen, each parcel was inked. Using a non-reproducible blue pencil, the polygon number and label were recorded (Figures 2 and 3).

Stratification Procedures

In order to evaluate the capability of a mapping system for a sampling frame, the mountain pine beetle infestation layers were stratified by intensity classes. The stratification procedure is outlined below:

The number of trees was first used as the polygon "label." Output from the mapping system provided the following table:

Polygon Number	Label (number of trees)	Acres
1	10,000	8,500
2	5,000	4,000
.	.	.
.	.	.
.	.	.
200	2,000	5,000

This information was input into a computer system developed especially for this study to compute trees/acre, producing the following table:

Polygon Number	Label (number of trees)	Acres	Trees Per Acre
1	10,000	8,500	1.18
2	5,000	4,000	1.25
.	.	.	.
.	.	.	.
.	.	.	.
200	2,000	5,000	.40

Then the data was sorted by descending order on trees/acre and another program was used to produce the following results:

Polygon Number	Label (number of trees)	Acres	Trees Per Acre	Accumulated Trees	Accumulated Acres
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
200	2,000	5,000	.40	100,000	200,000
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
1	10,000	8,400	1.18	152,000	585,000
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
2	5,000	4,000	1.25	182,000	696,000
.	.	.	.	.	.
.	.	.	.	.	.
.	.	.	.	.	.
last record	1,000	8,000	8.00	Total trees	Total acres

From the above table, the stratification boundaries were determined. The boundaries were somewhat arbitrary but an attempt was made to equalize the number of accumulated trees in each strata. Once the strata boundaries were established, then each polygon's label was changed to L, M, H (Tables 2 and 3). The use of L, M and H for light, medium and heavy are arbitrarily used and, for purposes of this study, have no biological meaning.

RESULTS

Acreage Estimates

Acreage estimates for PLOT and WRIS were extremely close and acceptable (Tables 1 through 5). Both systems can "get the job done." The computer base acreages were 1,023,750 and 1,029,796 for PLOT and WRIS respectively. The computer outputs from both systems are easily interpreted and can be transcribed to tabular form (Tables 1 through 5) immediately.

Computer Plots

Computerized plots are one form of output that is available. The plots can be for one layer individually, such as ownership only, or can contain the overlay between ownership and an insect layer. Both computer plots from the PLOT and WRIS system (Figures 4 and 5) contain the overlay of ownership and the 1976 mountain pine beetle strata.

Table 1. - Base layer, acreages by ownership, system for the northern half of the Targhee National Forest area, Idaho.

Ownership	Acreage estimates PLOT	Acreage estimates WRIS
Targhee National Forest	496,244	497,876
Private lands	198,865	200,562
Adjoining National Forest lands	197,879	199,781
Yellowstone National Park	139,762	131,577
Total base layer	1,023,750	1,029,796

Table 2. - 1975 mountain pine beetle layer, number of polygons, acres, trees, by system, intensity class, northern half of the Targhee National Forest, Idaho.

Intensity class trees/acre	PLOT			WRIS		
	Number of polygons	Acres	Trees	Number of polygons	Acres	Trees
1 (0-1.99)	139	205,959	151,740	139	207,812	151,740
2 (2-3.99)	28	64,387	178,000	28	64,772	178,000
3 (4 +)	12	31,413	180,000	12	31,680	180,000
Total	179	301,759	509,740	179	304,314	509,740

Table 3. - 1976 mountain pine beetle layer, number of polygons, acres, trees, by system, intensity class, northern half of the Targhee National Forest, Idaho.

Intensity class trees/acre	PLOT			WRIS		
	Number of polygons	Acres	Trees	Number of polygons	Acres	Trees
1 (0-.99)	156	174,142	67,470	156	176,084	67,470
2 (1-2.99)	46	71,972	121,850	46	72,535	121,850
3 (3 +)	17	25,210	102,000	17	25,338	102,000
Total	219	271,324	291,320	219	273,957	291,320

Table 4. - Ownership base overlayed with the 1975 mountain pine beetle infestation area, by system for northern half of the Targhee National Forest, Idaho.

PLOT

Intensity class	Acres infested: Targhee NF	Private lands	Adjoining NF	National Park	Total
1	194,913	10,790	33	228	205,964
2	54,074	10,251	- -	- -	64,325
3	28,943	2,421	- -	- -	31,364
Total	227,930	23,462	33	228	301,653

WRIS

Intensity class	Acres infested: Targhee NF	Private lands	Adjoining NF	National Park	Total
1	194,071	9,973	- -	309	204,353
2	54,366	9,867	- -	- -	64,233
3	28,953	2,316	- -	- -	31,269
Total	277,390	22,156	- -	309	299,855

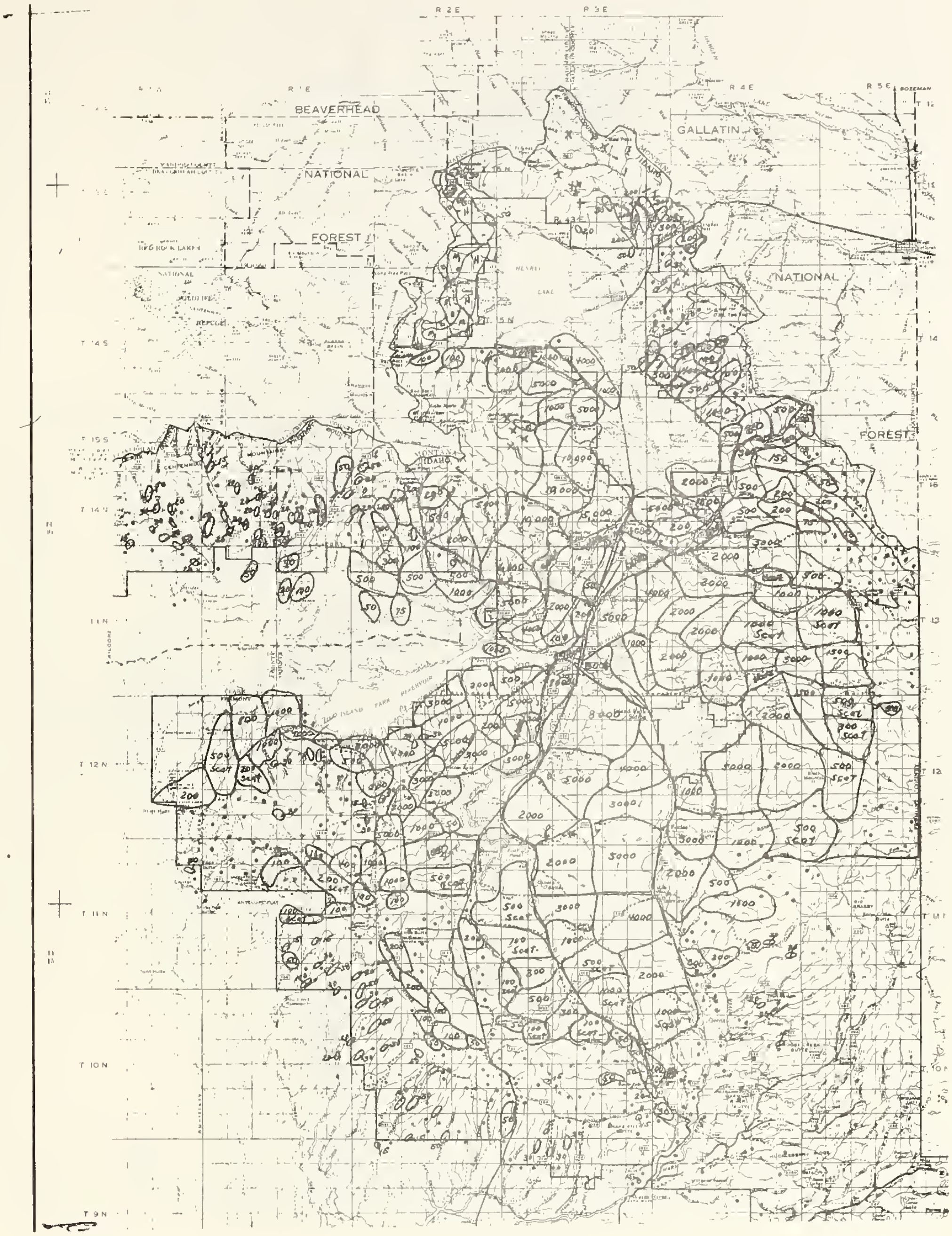

Figure 1.- Map of northern half of the Targhee National Forest area with 1976 mountain pine beetle infestation areas.

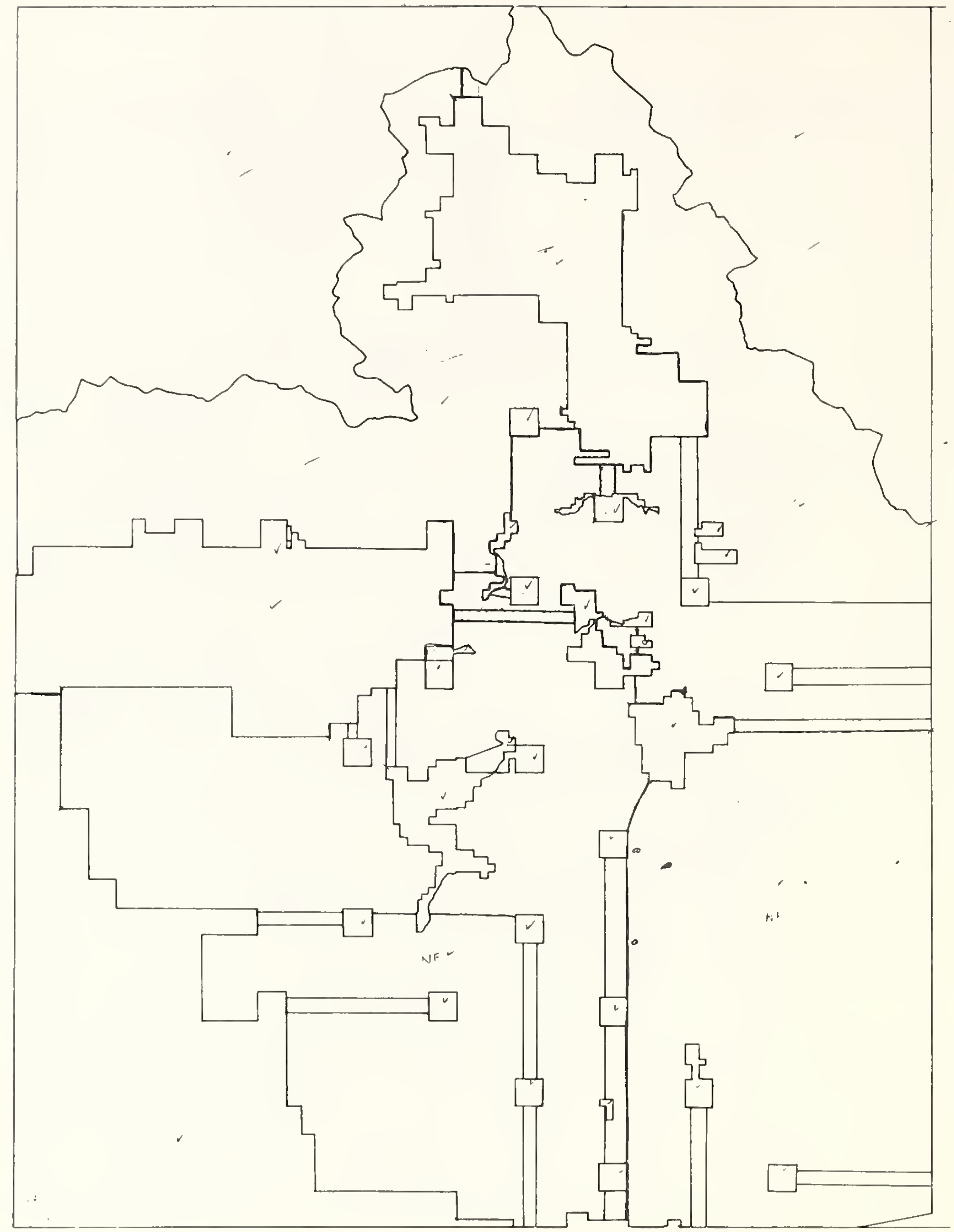

Figure 2.- Mylar overlay depicting the ownership pattern of the northern half of the Targhee National Forest area.

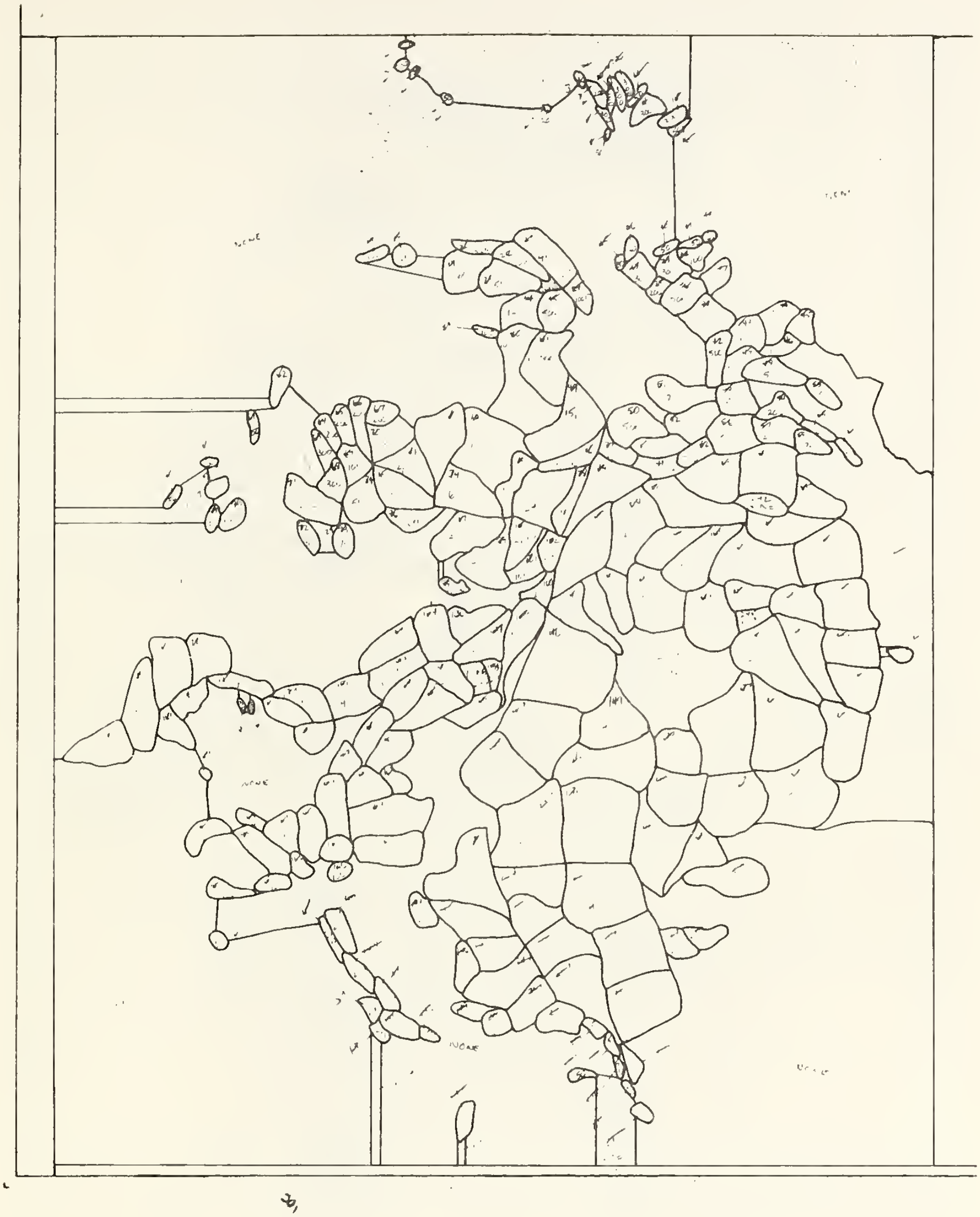

Figure 3.- Mylar overlay depicting the 1976 mountain pine beetle infestation areas of the northern half of the Targhee National Forest area.

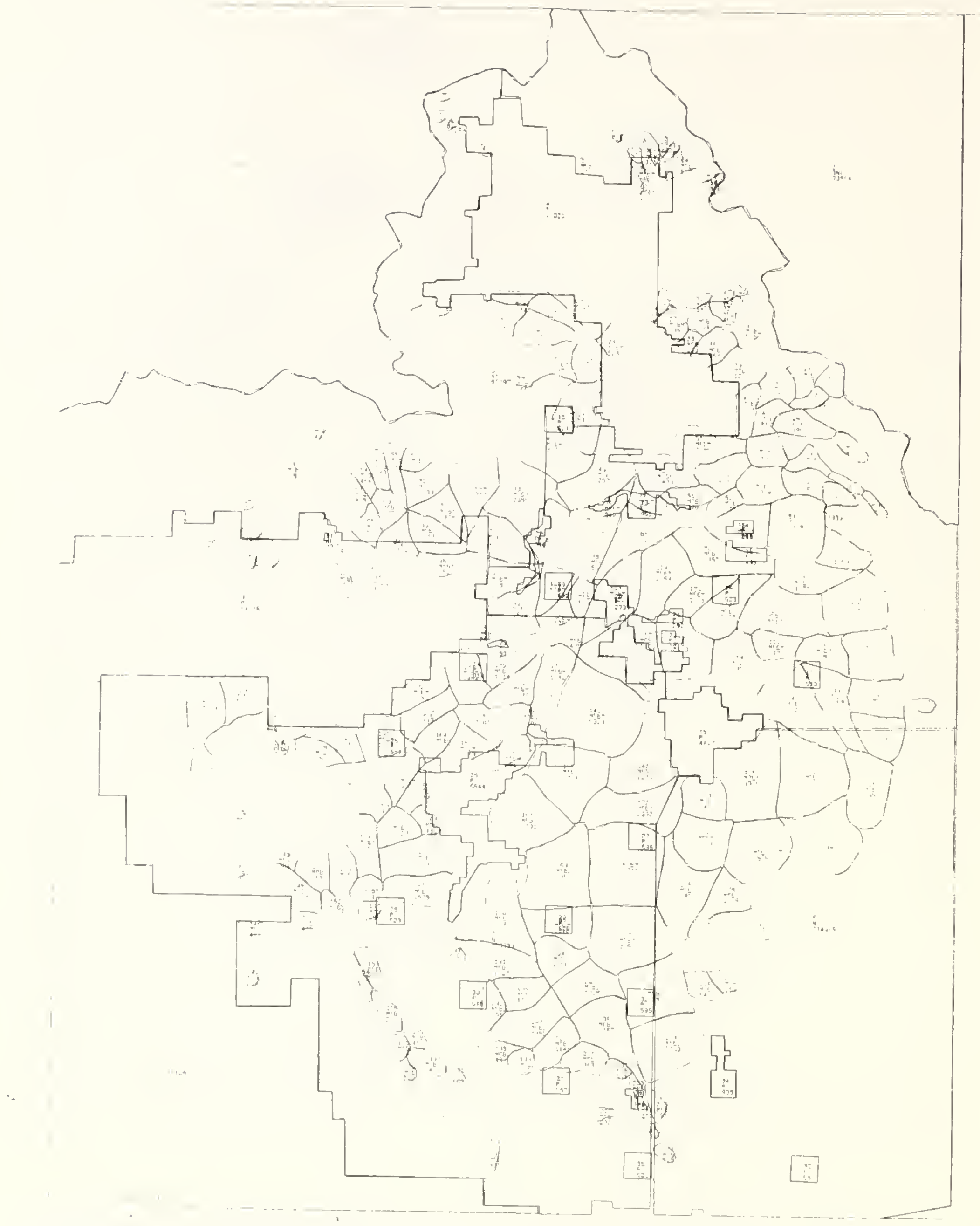

Figure 4.- Computerized plot from the PLOT system depicting the 1976 mountain pine beetle infestation area with the ownership layer for the northern half of the Targhee National Forest area.

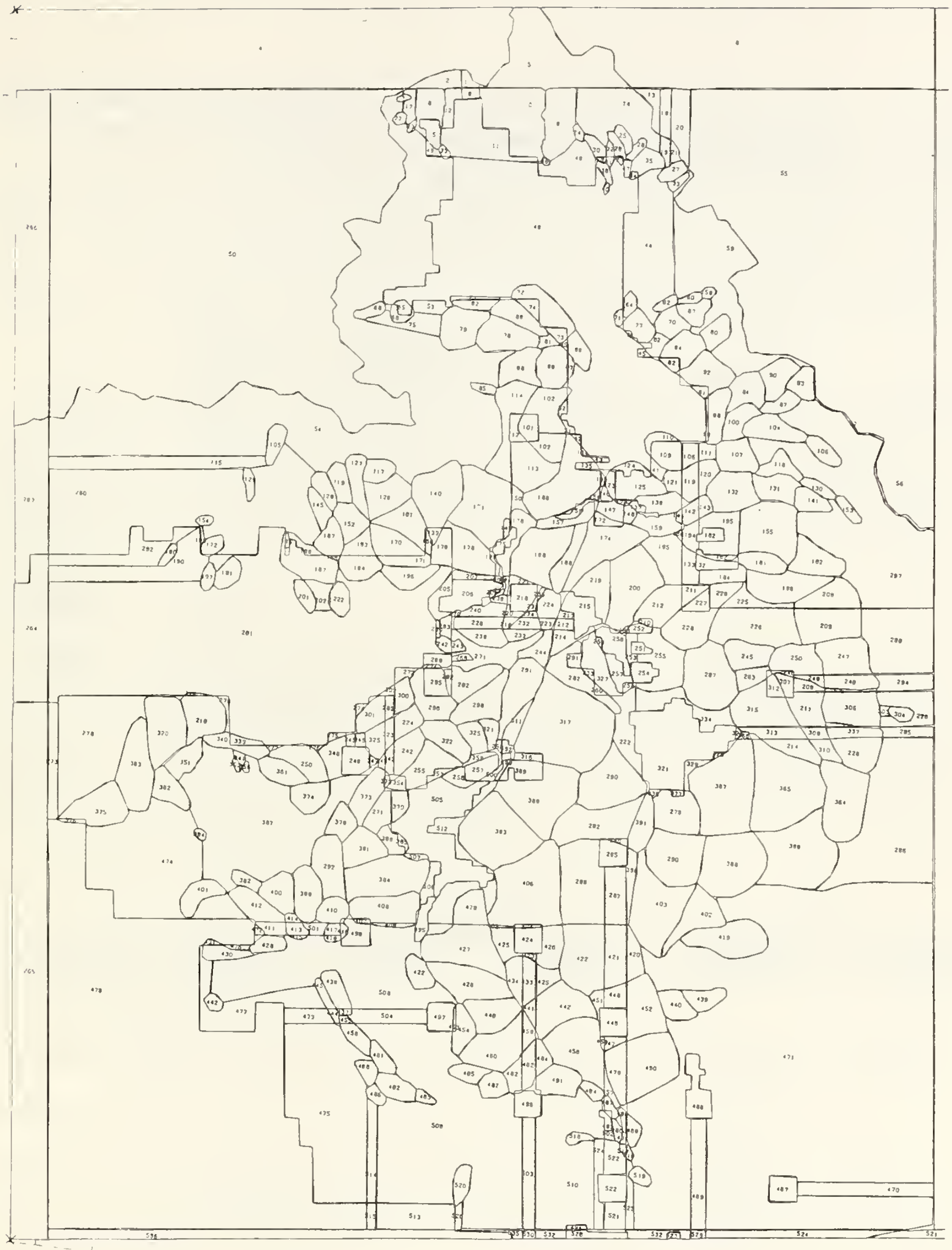

Figure 5.- Computerized plot from the WRIS system depicting the 1976 mountain pine beetle infestation area with the ownership layer for the northern half of the Targhee National Forest area.

Table 5. - Ownership Base Overlayed with the 1976 mountain pine beetle infestation area, by system for northern half of the Targhee National Forest, Idaho.

PLOT

Intensity class	Acres infested				
	Targhee NF	Private lands	Adjoining NF	National Park	Total
1	164,234	9,921	7	- -	174,162
2	61,647	10,173	- -	- -	71,820
3	22,647	2,621	- -	- -	25,268
Total	248,528	22,715	7	- -	271,250

WRIS

Intensity class	Acres infested				
	Targhee NF	Private lands	Adjoining NF	National Park	Total
1	163,910	9,371	- -	- -	173,281
2	61,417	10,044	- -	- -	71,461
3	22,565	2,411	- -	- -	24,976
Total	247,892	21,826	- -	- -	269,718

Time And Cost

Identified time and cost for the PLOT system to process three maps were 42 hours and $150. The time figure includes all the steps from preparing the mylar overlays to plotting the finished product. Costs incurred are the processing costs at the Fort Collins Computer Center only. No costs were incurred for the use of the digitizer or the plotter. Some charges for these items would probably occur under operational useage.

The costs incurred for the WRIS system was $300 per map or $900 for the three maps. The WRIS system is operational under contract by PSW and R-5 using the computer facilities at PSW and I.S.D., Santa Clara. The costs include computing, scanning, and plotting plus overhead for the system manager who did the work. The identified time for preparing the mylar overlays and working with the system manager was 45 hours.

Operational Problems

Both systems encountered computer problems during the overlay procedures. Specific details are not relevant to the report. The problems were identified, modifications made and final products were obtained. The crucial point worthy of bringing out is that complex systems must have the support mechanism to handle the problems that do occur in an operational framework.

CONCLUSIONS

A mapping system can become an effective tool in FI&DM operations. Specifically the system will do the following in conjunction with the aerial sketch map surveys:

1. Compute acreages of acres delineated from aerial detection maps.

2. Provide a historic data base for the same sets of maps.

3. Provide acreage tables of insects and diseases by political/ownership boundaries.

4. Provide acreage tables showing rate of change from one year to the next.

5. Provide a sampling frame for other FI&DM surveys. The mapping system allows us to stratify the forests into intensity classes for sampling projects. Also stratification could be based on years of continuous defoliation utilizing the historic data base.

6. Identify the boundaries of control projects.

We have all heard the cliche "garbage in - garbage out." It is appropriate to mention it here in discussing the mapping system as it applies to FI&DM. The finished product from the mapping system can certainly be no better than the information which goes into the system. Sketch map data is based on the individual observer's judgement of what he sees in the forest canopy when flying ca. 1000 feet above it at 90-120 m.p.h.

RECOMMENDATIONS

Choice of Sytem

The PLOT mapping system (or one very similiar) is more appropriate for FI&DM surveys. The decision is based on the author's interpretation of the bench mark results, mainly in the area of its overall operational simplicity. The following factors went into the decision:

1. Quality Of Input Data - hand digitizing is the most efficient way to enter data into the system. Small errors in the process are irrelevant based on how the raw data is obtained. Scanning the input data is not necessary (the WRIS system does accept hand digitized data, but is not currently part of the operational procedure.)

2. Timing - the PLOT system provides the finished product in three days for one map without the computerized plot, in five days with the computerized plot. The WRIS system involves additional time for preparing a photo for scanning (one week), determining label coordinates and keypunching labels (one to two days). Completion time for WRIS is about three weeks for one map.

3. Complexity Of System - (a) the PLOT system handles polygons within polygons, (b) the processing of PLOT on the computer is done with portable terminals in either batch mode or demand mode. This WRIS system cannot handle polygons within polygons without special handling. The major computer operation is with cards in batch mode.

4. Out-of-Pocket Costs - the PLOT system costs about $50-75 per map. The WRIS system, operated by contract with R-5 personnel, cost $300 per map.

Data Management System Interface

The outputs from the mapping system are unique for each map. A summary program can be developed to aggregate data for all of the maps in the Region, and used until a data management system is available. In order to insure that such systems are compatible to the mapping system, the following steps are being taken:

1. Preparing output specifications in tabular form for aerial detection surveys.

2. Presenting these specifications for implementation.

3. Monitoring the progress made in the area of the implementation of the Forest Service's data base system.

ACKNOWLEDGEMENTS

The following people were instrumental in assisting the author in conducting the evaluation. Bill Klein, Survey Specialist, FI&DM, Methods Application Group and Lynne Whyte, Biological Technician, FI&DM, Methods Application Group for preparing mapping materials; Tom Gregg, Forestry Technician, R-6, John Robertson, Management Systems Staff, R-6, and Robert Hubler, Computer Scientist, R-6 for PLOT system; Dave Blakeman, Forester (Information Specialist), R-5 and Dave Sharpnack, Research Forester, PSW for WRIS system; to the above individuals and to Tom George, RIDS Project Leader, WO-Geometronics, Wayne Bousfield, Entomologist, R-1, Doug Parker, Entomologist, R-3, and William Ciesla, Group Leader, FI&DM, Methods Application Group for reviewing the manuscript.

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APPENDIX

PLOT Procedures

Documentation for the PLOT system is maintained by the Management System Staff, R-6. Copies are available upon request. Figure 6 depicts the steps required to process PLOT. Discussion of each step follows:

1. Preparing Map Overlays - previously discussed.

2. Establishing Base Coordinates - PLOT is designed to provide for the overlaying of map layers to the same base map. Input must consist of map layers of identical scale and coordinate zero point prepared from a common base map. The base map used for the bench mark test was the ownership map for a portion of the Targhee National Forest area covering 1,023,750 acres. Each succeeding insect layer was calibrated using the same base coordinates.

3. Entering Labels/Hand Digitizing - the digitizing was done on a CALMA graphic digitizing system at Portland, Oregon. The digitizing table is approximately 4 by 5 feet, large enough to handle Forest Service series maps. An external keyboard was used to enter the labels for a polygon as each was digitized. Output for each map was recorded on separate large magnetic tapes.

4. Transmit Digitized Data Tape To The Fort Collins Computer Center - the magnetic tapes were transmitted to FCCC via the R-6 Data 100 Batch Terminal. Separate disk files were made for each map at FCCC.

5-6. Edit Data - the edit phase occurs at two places: (1) reviewing the raw data listing of the digitized data, and (2) running the "editor" program. Certain obvious errors can be detected by reviewing the raw data listings. These errors are caused by mistakes in the digitizing process. If errors are detected, the errors can be corrected using the FCCC text editor, preferably in batch mode. The edit program (editor) was then run. The execution of all the computer jobs for steps (5) through (10) were made from an Execuport portable terminal. Most of the jobs were run in batch mode. The editor program computes the area of each polygon and prints out the polygon number, label and acres. The editor prints out error messages for polygons with errors; the most common error occurs when the digitizer (operator) did not finish the polygon at the starting place, leaving a gap in the polygon.

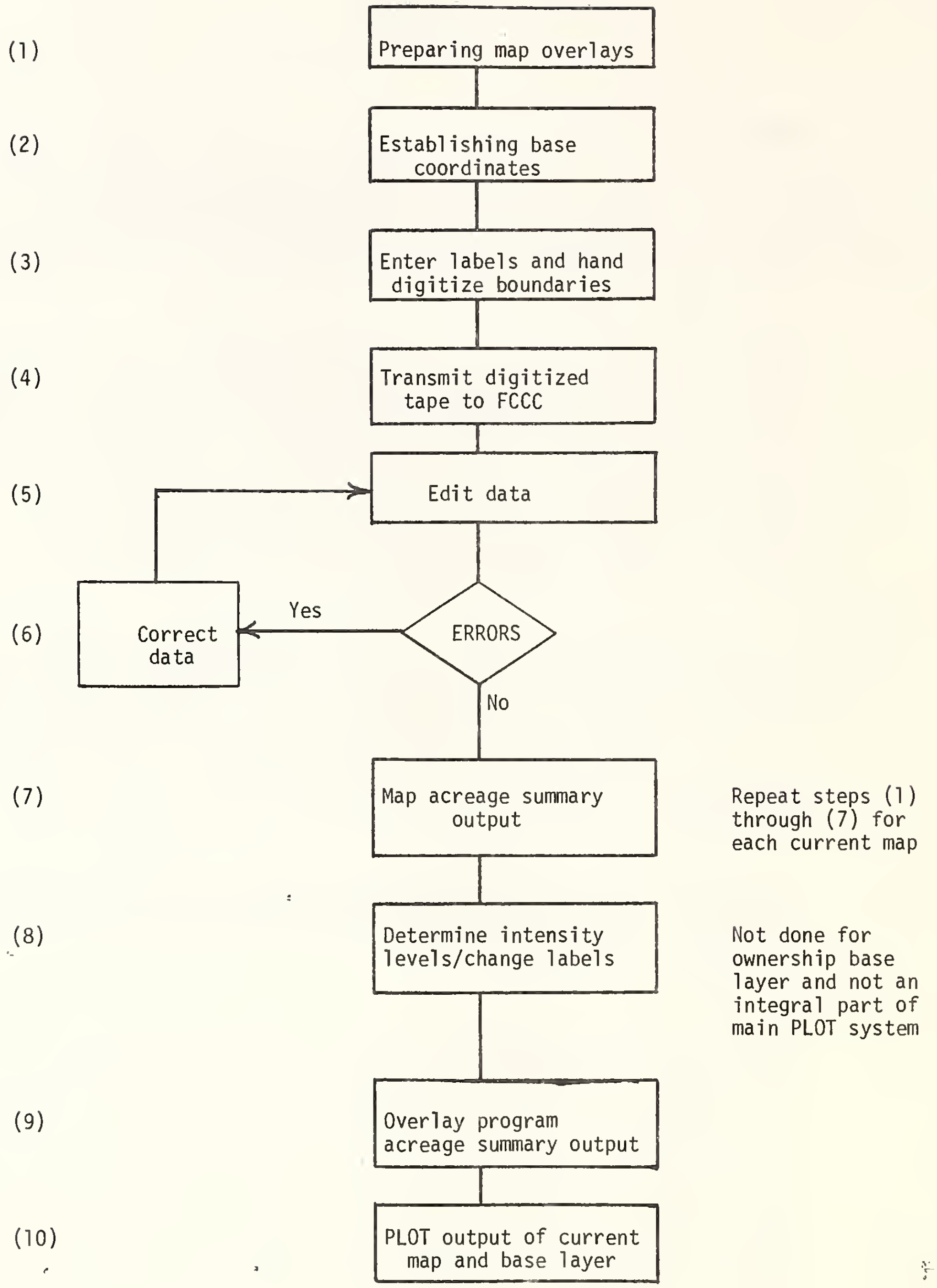


Figure 6: Flow Chart For Running PLOT

7. Acreage Summary Output - the next program to be run is DONUTS. The purpose of this program is to subtract out the area of a smaller polygon inside of a larger polygon to obtain net acres for the larger polygon. Output of DONUTS include an acreage summary by polygon label.

8. Determining Intensity Levels/Change Labels - for the 1975 and 1976 insect maps intensity levels were determined and the labels for each polygon was changed internally by a special program written for this task. A final output summary was obtained by running acres giving the number and percent of polygons, acres, and percent of acres by polygons of all common labels.

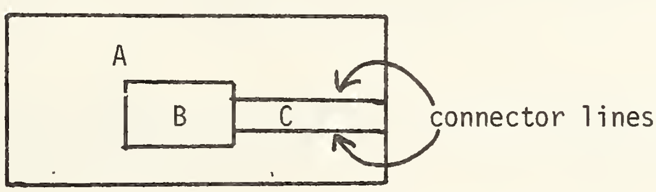
9. Overlay Program - following the base layer and insect layer, the overlay programs were run for base X 1975 and base X 1976.

10. Plot - graphical plots were made for the ownership and 1975 insect layers combined and for the ownership and 1976 insect layers combined. A plot tape was created at FCCC and was transmitted to the Regional Office's Data 100 Batch Terminal. The tape created from the Data 100 was then converted to a seven track tape used for off-line plotting on a CALCOMP plotter.

WRIS Procedures

Figure 7 is the flow chart depicting the primary steps used for the evaluation. For more detailed instructions, refer to the WRIS users guide (Russell *et al.*, 1975).

1. Preparing Map Overlays - in addition to the procedures previously discussed, connector lines were drawn in for parcels of land within another parcel in order to handle "DONUTS." Example:



Parcel B is within parcel A. Connector lines were drawn to handle that situation. A "dummy" polygon C is created and becomes part of the system.

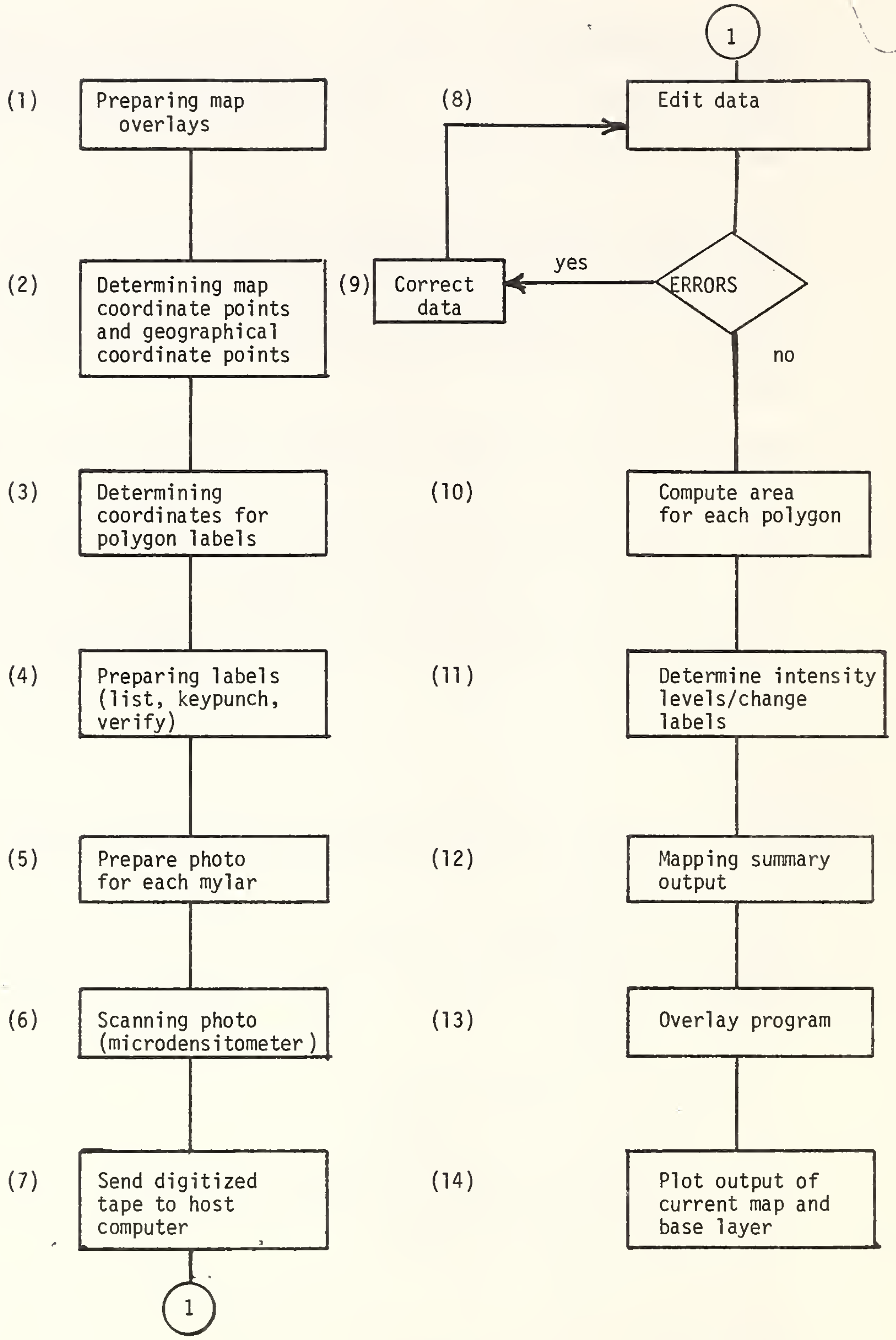


Figure 7: Flow Chart For Running WRIS

2. <u>Determining Map Coordinate Points And Geographical Coordinate Points</u> - each map had a physical parameter inked. Latitude and longitude values were determined for each of the four boundary points on the parimeter. X, Y coordinates were determined for each of the same four points based on an X, Y coordinate system (graph paper, 100 squares per square inch).

3. <u>Determining Coordinates For Polygon Labels</u> - each polygon on the mylar must have a label name. In order for the label to be associated to the correct polygon, X, Y coordinates must be determined "somewhere" inside each polygon. An X, Y coordinate system (graph paper, 100 squares per square inch) is used to manually determine the X, Y values.

4. <u>Preparing Labels</u> (list, keypunch, and verify) - after the X, Y coordinates have been determined, a listing is prepared showing for each polygon the label name and the associated X, Y values. This listing is then keypunched and verified.

5. <u>Preparing Photo For Each Mylar Layer</u> - the larger mylar overlays, approximately 3 x 3 feet are photographically reduced to a size of 4 x 4 inches. A negative is produced which is used by the optical scanner.

6. <u>Scanning Data</u> - the photo negative is electronically scanned using a microdensitometer. A digitized tape is produced from the operation.

7. <u>Send Digitizer Tape To Host Computer</u> - WRIS is used operationally at the Information Systems Design, (ISD), Computer Center in Santa Clara, California. The system is operable at FCCC but not used there by PSW or R-5.

8. <u>Edit Data</u> - once the digitized tapes are on site, all of the computer jobs are run in batch mode. An edit program edits the digitized data and provides an edit listing showing portions of the map that need changes. The printout shows polygons that did not close and/or areas where there are too many points.

9. <u>Correct Data</u> - the data files are corrected by locating where the problem occurs in X, Y coordinates. Adds and deletes are keypunched for an update through the program POLLY.

10. <u>Compute Area For Each Polygon</u> - after the files have been edited, the program TONIC computes the area for each polygon and produces a listing showing polygon number, label, acres, and totals for all similar labels.

11. Determining Intensity Levels/Change Labels - for 1975 and 1976 MPB maps, intensity levels were determined and the labels for each polygon were changed.

12. Mapping Summary Output - the summary program TONIC was run again providing acreage summary by intensity class.

13. Overlay Program - following the clean runs for the three maps ownership, 1975 and 1976 MPB, overlays were produced for base X 1975 and base X 1976.

14. Plotting Output Data - two maps were produced (a) base and 1975 and (b) base and 1976.

Projected Time, Equipment, And Cost Requirements For Implementation

The following projections are based on one Forest Service Region with 50 maps (mylar layers). Using ½-inch scale maps, a good workable size map for the system is about 2 x 2 feet. Some National Forest areas would require up to four maps.

1. Equipment Needed

   a. Large digitizing table.

   b. Batch terminal to transmit and receive data.

   c. Large plotter.

   d. Portable terminals (2).

All Regions have and are using large digitizing equipment. In order for FI&DM personnel to use the equipment, advance scheduling would be necessary. It is conceivable that the equipment could not be made available to the FI&DM staff for a block of six weeks. In that case, they might have to augment the equipment by purchasing an add-on digitizing table for their use.

All Regions have high speed (4800 or greater baud) batch terminals linked to FCCC. The impact on using the terminal would not be significant. Advance scheduling would be necessary to achieve the needed turnaround time.

All Regions have large plotting capabilities which could be made available to FI&DM units. Some internal-charge back for use would probably have to be established. Again, advance scheduling would have to be made.

Portable terminals would have to be dedicated to the operation during the six to eight week period. Most FI&DM units have at least one unit now. To relieve the impact on the regular work being done, it would be advisable to have one terminal dedicated to the mapping system.

2. Time and Manpower Requirements (based on 50 maps).

   a. Preparation of Mylar overlays
      5 hours per map
      1 GS-4/5 for six weeks

   b. Hand digitizing
      3 hours per map
      1 GS-4/5 for 4 weeks

   c. Process data
      8 hours per map
      2 people for 5 weeks, GS-9, 11

   d. Aggregate data from 50 maps to District, Forest, Region level
      2 people for 2 weeks, GS-11, 12

   e. Manager for sytem
      2 months, GS-11

The manager of the system would be an FI&DM specialist having the following responsibilities.

1. Scheduling all operations.

2. Training people.

3. Supervising.

4. Data manager (keeping track of where everything is in the computer).

5. Setting up special runs for FI&DM professionals, i.e., spruce budworm defoliation in one forest.

It is possible that all of the jobs needed to be done could be done by existing personnel. The people who are currently processing aerial sketch map data by hand would be utilized.

3. Cost to operate.

a. Processing costs at Fort Collins

2 edit runs	$10	
summary run	20	
2 overlays	30	
plotting	15	
total per map	75	
Total per 50 maps		$3,750

b. Tape and disk storage

50 tapes per year ($12/year/tape)	600

c. Aggregation runs — 500

d. Special runs during year — 500

e. File maintenance and updating — 650

Total projected FCCC costs — $6,000

The $6,000 cost is a rough estimate for one Region per year. It is extremely difficult to project the fully operational costs.

4. Timetable

In order to be an effective system, all data would have to be processed and summarized in two months. If the aerial survey begins on August 1, all of the maps would be completed by October 1.